

with an extended monitoring period at the repository, the range values would triple to \$167 billion to \$184 billion (in 2001 dollars). The estimated cost for the remaining 9,700 to 9,900 years of Scenario 1 would range from \$519 million to \$572 million per year. There would be no costs under Scenario 2 after the first 100 years because that scenario assumes no effective institutional control after that time.

## **S.4 Issues Raised by the Public**

### **S.4.1 Issues Raised in Public Scoping**

DOE solicited written comments and held 15 public scoping meetings across the country between August 29 and October 24, 1995, to enable interested parties to present comments on the scope of this EIS.

During the public scoping process, a number of commenters asked that the EIS discuss the history of the Yucca Mountain site characterization program and requirements of the NWPA, address DOE's responsibility to begin accepting waste in 1998, describe the potential decisions that the EIS would support, and examine activities other than construction, operation and monitoring, and closure of a repository at Yucca Mountain. Other comments raised during public scoping addressed the consistency of the proposed repository with existing land uses, effects of earthquakes and volcanism, health and safety impacts, long-term impacts, and sabotage. In response to the public's input, DOE included discussions and analyses of these issues in the EIS. DOE also received comments noting that the Nation will have more than 70,000 MTHM of spent nuclear fuel and high-level radioactive waste, although the NWPA directs that the maximum amount allowed for repository disposal is 70,000 MTHM of these materials until a second repository is in operation. Commenters encouraged DOE to evaluate the disposal of the entire anticipated inventory of spent nuclear fuel and high-level radioactive waste and other waste types that might also require permanent isolation. For this reason, the EIS analyzes cumulative environmental impacts that could occur from the disposal at Yucca Mountain of the country's total projected inventory of spent nuclear fuel and high-level radioactive waste, as well as Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. In response to other public scoping comments, DOE added an additional transportation corridor and route in Nevada to the analysis.

Many other public scoping comments presented views and concerns not related to the scope or content of the Proposed Action. Examples of these comments include statements in general support of or opposition to a repository at Yucca Mountain, geologic repositories in general, and nuclear power; lack of public confidence in the Yucca Mountain program; perceived inequities and political aspects of the siting process by which Congress selected Yucca Mountain for further study; the constitutional basis for waste disposal in Nevada; legal issues involving Native American land claims and treaty rights; and unrelated DOE activities. DOE considered and recorded these concerns, but has not included analyses of these issues in the EIS.

### **S.4.2 Issues Raised on the Draft EIS and the Supplement to the Draft EIS**

During the public comment process for the Draft EIS and the Supplement to the Draft EIS, commenters raised a variety of key issues. DOE identified issues as "key" based on factors such as:

- The extent to which an issue concerned fundamental aspects of the Proposed Action
- The nature of the comments as characterized by the commenter
- The extent to which DOE modified the EIS in response to the issue
- The number of comments received on a particular issue

The Comment-Response Document contains the comments received on the Draft EIS and on the Supplement to the Draft EIS and the DOE responses to those comments. The following summaries illustrate some of the key issues and DOE's responses.

- *Nuclear Waste Policy Act – Why is Yucca Mountain the only site that DOE is studying?*

The Nuclear Waste Policy Act of 1982 provided for a process for selecting sites for technical study as potential geologic repository locations. In accordance with this process, DOE identified nine candidate sites, the Secretary of Energy nominated five of the nine sites for further consideration, and DOE issued environmental assessments for the five sites. DOE recommended three of the five sites, of which Yucca Mountain was one, for possible study as candidate repository sites. In 1987, Congress amended the Nuclear Waste Policy Act of 1982, directing the Secretary of Energy to perform site characterization activities only at the Yucca Mountain site, and, if the site was found suitable, to make a determination whether to recommend that the President approve the site for development of a repository.

- *DOE's site suitability guidelines – Why did DOE change its guidelines for determining the suitability of the Yucca Mountain site?*

The Nuclear Waste Policy Act of 1982 directed the Secretary of Energy to issue general guidelines for the recommendation of sites for characterization, in consultation with certain Federal agencies and interested governors, and with the concurrence of the Nuclear Regulatory Commission. These guidelines (issued in 1984 at 10 CFR Part 960) included factors related to the comparative advantages among candidate sites located in various geologic media, and other considerations such as population density and distribution.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason, DOE proposed in 1996 to clarify and focus its 10 CFR Part 960 guidelines to apply only to the Yucca Mountain site. In 1999, DOE proposed further revisions to these guidelines principally to reflect the then-proposed regulations and criteria of the Environmental Protection Agency (40 CFR Part 197) and the Nuclear Regulatory Commission (10 CFR Part 63), and to provide a technical basis to assess the performance of a geologic repository at Yucca Mountain to isolate spent nuclear fuel and high-level radioactive waste from the environment.

In 2001, DOE promulgated its final guidelines (10 CFR Part 963), establishing the methods and criteria to determine the suitability of the Yucca Mountain site for the location of a geologic repository. The Final EIS describes these final guidelines.

- *Repository design – Why design a repository that would release radioactive materials into the environment?*

Given the current state of technology, it is virtually impossible to design and construct a geologic repository that would provide a reasonable expectation that there would never be any releases of radioactive materials. DOE would design and construct a repository that would meet public health and safety radiation protection standards and criteria established by the EPA and the NRC. In part, the EPA standards (40 CFR Part 197) and NRC criteria (10 CFR Part 63) prescribe radiation exposure limits that the repository, based on a performance assessment, must be designed not to exceed during a 10,000-year period after closure.

In the EIS, DOE has evaluated the environmental impacts of the proposed repository's natural and engineered barrier system, which is designed to isolate radioactive materials from the environment for thousands of years. As a result of this evaluation, DOE would not expect the repository to result

in impacts to public health beyond those that could result from the prescribed radiation exposure and activity concentration limits during the 10,000-year period after closure.

- *Public participation process – Commenters stated that the public comment processes for scoping, the Draft EIS, and the Supplement to the Draft EIS were inadequate.*

DOE's public involvement process during the development of the EIS is consistent with Council on Environmental Quality and DOE regulations implementing NEPA, and reflects DOE guidance on public participation during the preparation of EISs.

For the scoping process and in advance of the Notice of Intent, DOE notified its stakeholders of its plans to prepare the EIS and its approach to the scoping process. When the Notice of Intent was published in the *Federal Register*, DOE mailed a series of information releases to stakeholders, sent press releases and public service announcements to the media, and provided information on the Internet and in its reading rooms. Fifteen public scoping meetings were held during a 120-day public scoping period.

In August 1999, DOE distributed the Draft EIS to more than 3,400 stakeholders and held 21 public hearings across the Nation during a 199-day public comment period. DOE placed advertisements in local newspapers and distributed public service announcements and press releases to more than 175 local and national stakeholder and media outlets to publicize information about the Draft EIS and public comment process.

In May 2001, DOE distributed the Supplement to the Draft EIS to more than 4,000 stakeholders and held three public hearings in Nevada during the 57-day public comment period. During this period, the Department discovered that it had inadvertently not sent the Supplement to about 700 stakeholders who had requested and received a copy of the Draft EIS. DOE acknowledged this oversight, provided copies of the Supplement to the Draft EIS, and provided a separate 45-day comment period for these stakeholders.

In Volume III of this EIS, DOE has presented and responded to all comments on the Draft EIS and the Supplement to the Draft EIS received by August 31, 2001.

- *Need for another Draft EIS or a Supplemental EIS – The Draft EIS did not provide sufficient information or analysis and, thus, was deficient and should be withdrawn.*

The level of information and analyses, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts, and the use of bounding assumptions to address incomplete or unavailable information or uncertainties provide an assessment of environmental impacts consistent with all applicable requirements.

The EIS, which DOE prepared using the best reasonably available data, analyzes a variety of implementing alternatives and scenarios. These alternatives and scenarios reflect potential repository design and operating modes, waste packaging approaches, and transportation options for shipping spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site. DOE included a No-Action Alternative that analyzed two scenarios to provide a basis for comparison with the Proposed Action and to reflect the range of impacts that could occur.

In the Draft EIS, DOE discussed ongoing site characterization activities and design evaluations, and the potential for resulting changes to repository design. Since the publication of that document, DOE improved its understanding of the interactions of potential repository features with the natural environment, and the advantages of a number of design features to enhance waste containment and

isolation. DOE published the Supplement to the Draft EIS to address the most recent design enhancements, including various operating modes to manage heat generated by emplaced spent nuclear fuel and high-level radioactive waste.

This Final EIS evaluates the Proposed Action based on the design considered in the Supplement to the Draft EIS.

- *Range of alternatives – DOE should have considered a range of alternatives, such as other sites, treatment technologies, and alternatives to geologic disposal.*

In 1980, DOE evaluated alternatives to mined geologic disposal in an EIS, and decided in 1981 in the subsequent Record of Decision to develop mined geologic repositories for the disposal of spent nuclear fuel and high-level radioactive waste. Furthermore, the NHPA provides that DOE need not consider in this EIS the need for a geologic repository and alternatives to isolating spent nuclear fuel and high-level radioactive waste in a repository. The NHPA also provides that this EIS does not have to consider any site other than Yucca Mountain for development as a repository. For these reasons, DOE did not analyze alternatives other than the Proposed Action and the No-Action Alternative.

- *The Proposed Action – DOE has failed to define its Proposed Action clearly.*

In response to this concern, DOE has modified the EIS to promote an improved understanding of the potential environmental impacts from a more specifically defined Proposed Action. DOE has identified its preferred alternatives, simplified aspects of the Proposed Action, and modified its analyses and presentation of information to illustrate the full range of potential environmental impacts that could occur under any reasonably foreseeable repository design and operating mode or mode of transportation.

- *Preferred alternative – DOE should identify its preferred alternatives and scenarios.*

In the Draft EIS, DOE indicated its preferred alternative was to proceed with the Proposed Action to construct, operate and monitor, and eventually close a repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. In this Final EIS, DOE has identified mostly rail as its preferred mode of transportation, both nationally and in the State of Nevada.

DOE has not identified a preference among the five candidate rail corridors in Nevada. If the Yucca Mountain site was approved, DOE would issue at some future date a Record of Decision to select a mode of transportation. If, for example, mostly rail was selected (both nationally and in Nevada), DOE would then identify a preference for one of the rail corridors in consultation with affected stakeholders, particularly the State of Nevada.

DOE has not identified other preferences under the various scenarios presented in this Final EIS. Specific details of operating the repository and related features would be resolved only in the context of developing a License Application for review by the NRC.

- *No-Action Alternative – Why did DOE evaluate a No-Action Alternative that includes unreasonable scenarios?*

If the Yucca Mountain site was not approved, DOE would, as required by the NHPA, prepare a report to Congress, with the Department's recommendations for further action to ensure the safe, permanent disposal of spent nuclear fuel and high-level radioactive waste, including the need for new legislative authority. In this event, the generator sites, commercial utilities, and DOE would have to continue managing spent nuclear fuel and high-level radioactive waste in a manner that protected public health

and safety and the environment. However, the future course that Congress, DOE, and the commercial utilities would take is uncertain, and a number of possibilities could be pursued.

In light of these uncertainties, DOE decided to illustrate the range of potential environmental impacts by analyzing two No-Action Alternative scenarios that could occur without additional legislation—long-term storage of spent nuclear fuel and high-level radioactive waste at the current sites with effective institutional control for at least 10,000 years, and long-term storage with no effective institutional control after about 100 years. Although the Department agrees that neither of these scenarios is likely, it selected them for analysis because they provide a basis for comparison to the impacts of the Proposed Action and because they reflect a range of the impacts that could occur.

- *Decisionmaking – DOE cannot base decisions on this EIS.*

DOE believes that the EIS adequately analyzes the potential environmental impacts that could result from the Proposed Action. This belief is based on the level of information and analysis, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts, and the use of bounding assumptions where information is incomplete or unavailable, or where uncertainties exist.

For the same reasons, if the site was approved, DOE believes that the EIS provides the environmental impact information necessary to make certain broad transportation-related decisions, namely the choice of a national mode of transportation outside Nevada (mostly rail or mostly legal-weight truck), the choice among alternative transportation modes in Nevada (mostly rail, mostly legal-weight truck, or heavy-haul truck with use of an associated intermodal transfer station), and the choice among alternative rail corridors or heavy-haul truck routes with use of an associated intermodal transfer station in Nevada. However, follow-on implementing decisions, such as the selection of a specific rail alignment in a corridor, would require additional NEPA reviews.

- *Premature decisionmaking – DOE has decided to recommend the Yucca Mountain site in advance of the Final EIS and other documentation.*

At the time DOE prepared this Final EIS, it had not made a decision on the proposed repository at Yucca Mountain. The Secretary of Energy will make a determination on whether to recommend the site to the President on the basis of a number of different types of information, including that contained in the Final EIS. Any recommendation would be accompanied not only by the Final EIS, but also by other information designated in the NWPA.

- *Population data – Why does DOE use outdated population data?*

When DOE prepared the Draft EIS, it based the Nevada population estimates on the then-most-recently available information (1996-1997) from the U.S. Bureau of the Census. The Department used these data in its economic and demographic forecasting model to project population growth in the regions of influence and to evaluate socioeconomic impacts from the Proposed Action. For its transportation health and safety analyses, however, DOE relied on 1990 population data, which were the then-most-recent data incorporated in the standard models used for such analyses.

In response to comments and recently available information, DOE has updated its population estimates in the regions of influence to reflect the most recent state and local information, as well as the Bureau of the Census 2000 population summary data for Nevada. To update the health and safety analyses associated with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast the population to 2035 and scaled the impacts accordingly. To

update the health and safety analyses on a national basis, DOE scaled the 1990 population-based impacts upward to reflect the relative state-by-state population growth to 2035. The projections are based on 2000 Census data.

- *Risk perception and stigma – Why didn't DOE analyze the impacts associated with the negative perceptions attached to a potential repository at Yucca Mountain?*

During scoping for the EIS, DOE received comments saying the EIS should analyze perception-based and stigma-related impacts. Perception-based impacts would not necessarily depend on the actual physical impacts or risks from repository operations or transportation. Further, people do not consistently act in accordance with negative perceptions, and thus the connection between public perception of risk and future behavior would be uncertain or speculative at best. For these reasons, DOE determined that including analyses of perception-based and stigma-related impacts in the Draft EIS would not provide meaningful information.

Nevertheless, in light of the comments received on the Draft EIS, DOE commissioned an examination of relevant studies and literature on perceived risk and stigmatization of communities to determine whether the state of the science in predicting future behavior, based on perceptions, had advanced sufficiently to allow DOE to quantify the impact of public risk perception on economic development or property values. Based on this examination, DOE has concluded that:

1. While in some instances risk perceptions could result in adverse impacts on portions of a local economy, there are no reliable methods whereby such impacts could be predicted with any degree of certainty,
2. Much of the uncertainty is irreducible, and
3. Based on a qualitative analysis, adverse impacts from perceptions of risk would be unlikely or relatively small.

While stigmatization of southern Nevada can be envisioned under some scenarios, it is not inevitable or numerically predictable. Any such stigmatization would likely be an aftereffect of unpredictable future events, such as serious accidents, which are not anticipated to occur. As a consequence, DOE did not attempt to quantify any potential for impacts from risk perceptions or stigma in this Final EIS.

- *Native American viewpoints – DOE did not adequately consider Native American viewpoints or incorporate these viewpoints in the analyses and resulting conclusions.*

DOE believes that it appropriately considered Native American viewpoints by incorporating in the EIS the Native Americans' own identification of potential impacts to historic and other cultural resources important to sustaining and preserving their cultures. During the preparation of the EIS, DOE supported the American Indian Writers Subgroup of the Consolidated Group of Tribes and Organizations in its preparation of a separate report, the results of which are included in the EIS.

Based on the results of the report, DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on free access to the area around the repository site. Furthermore, the presence of a repository would represent an intrusion into what Native Americans consider an important cultural and spiritual area. These concerns notwithstanding,

DOE and the Consolidated Group of Tribes and Organizations recognize that restrictions on public access to the area have been generally beneficial and protective of cultural resources, sacred sites, and traditional cultural properties.

- *Ruby Valley Treaty – DOE should honor the Ruby Valley Treaty of 1863 with the Western Shoshone Nation.*

The Western Shoshone people maintain that the Ruby Valley Treaty of 1863 gives them rights to 97,000 square kilometers (37,000 square miles) in Nevada, including the Yucca Mountain region. In 1977, the Indian Claims Commission granted a final award to the Western Shoshone people, who dispute the Commission's findings and have not accepted the monetary award for the lands in question. In 1985, the Supreme Court ruled that even though the money has not been distributed, the United States has met its obligations with the Indian Claims Commission's final award and, as a consequence, the aboriginal title to the land has been extinguished.

- *Approach to environmental justice transportation analysis – DOE's two-staged assessment process masks significant impacts to minorities and low-income populations, and its failure to identify either specific locations or specific characteristics of affected communities demonstrates the inadequacy of the analysis.*

The approach to environmental justice analysis in this EIS is consistent with the Council on Environmental Quality guidance. The goal of this approach is to identify whether any high and adverse impacts would fall disproportionately on minority and low-income populations. The approach first analyzes the potential impacts on the general population as a basis for comparison. Second, based on available information, the approach assesses whether there are unique exposure pathways, sensitivities, or cultural practices that would result in high and adverse impacts on minority and low-income populations. If high and adverse impacts on a minority or low-income population would not appreciably exceed the same type of impacts on the general population, no disproportionately high and adverse impacts would be expected.

In response to comments, DOE has reevaluated available information to determine whether the Draft EIS overlooked any unique exposure pathways or unique resource uses that could create opportunities for disproportionately high and adverse impacts to minority and low-income populations. Although DOE identified additional unique pathways and resources, none revealed a potential for disproportionately high and adverse impacts.

DOE also updated and refined information germane to its environmental justice analysis. Based on the additional information and resulting analysis, DOE has concluded that disproportionately high and adverse impacts from the construction and operation of a rail line or intermodal transfer station would be unlikely.

- *Rail and highway routes – Why didn't DOE identify the specific rail and highway routes that would be used to ship spent nuclear fuel and high-level radioactive waste?*

Because it is impossible to predict which highway routes or rail lines DOE could use in advance of actual shipments, the Department selected potential highway routes for analysis in accordance with U.S. Department of Transportation regulations, which require the use of preferred routes (typically highways and bypasses that are part of the Interstate Highway System). The Department based its selection of potential rail routes on current rail practices, because there are no comparable Federal regulations applicable to the selection of rail routes for the shipment of radioactive materials.

In response to public comments, DOE has included maps of the representative highway routes and rail lines it used for analysis in the Final EIS. It also included potential health and safety impacts associated with shipments for each state through which shipments could pass.

- *Transportation public health and safety impacts – The transportation-related health and safety analysis was inadequate because DOE did not consider community-by-community population characteristics.*

DOE does not believe that it is necessary or appropriate to consider population characteristics on a community-by-community basis to determine potential public health and safety impacts from the transportation of spent nuclear fuel and high-level radioactive waste. The use of widely accepted analytic tools, latest reasonably available information, and cautious but reasonable assumptions if there are uncertainties, offer the most appropriate means to arrive at conservative estimates of transportation-related public health impacts.

In this EIS, DOE used computer models it has used in previous EISs and other studies. These models, such as RADTRAN 5, are widely accepted by the national and international scientific and regulatory communities.

In addition, DOE has either incorporated information that has become available since the publication of the Draft EIS or modified existing information to accommodate conditions likely to be encountered over the life of the Proposed Action. For example, in this Final EIS DOE has scaled impacts upward to reflect the relative state-by-state population growth to 2035, using 2000 Census data.

Not all aspects of incident-free transportation or accident conditions can be known with absolute certainty, and so DOE has relied on conservative assumptions that tend to overestimate impacts. For instance, DOE assumed that a hypothetical individual, the “maximally exposed individual,” would be a resident living 30 meters (100 feet) from a point where all truck shipments would pass (this individual would receive a dose of about 6 millirem). Although it can be argued that individuals could live closer to these shipments, it is highly unlikely that an individual would be exposed to all shipments over the 24-year period of shipments to the repository, even though DOE incorporated this highly conservative assumption in the analysis.

In response to comments, DOE has considered locations at which individuals could reside nearer the candidate rail corridors and heavy-haul truck routes in Nevada as a way of representing conditions that could exist anywhere in potentially affected communities. For example, an individual residing as close as 4.9 meters (16 feet) to a potential heavy-haul truck route would receive an estimated dose of about 29 millirem if exposed to all shipments.

The doses from these exposures would be well below those received from natural background radiation and would not be discernible even if the doses could be measured.

- *Transportation accident conditions – Why didn't DOE analyze a range of accidents that reflect real-life conditions?*

“Real-life conditions” that would involve various types of collisions, various natural disasters, specific locations (such as mountain passes), or various infrastructure accidents (such as track failure) in effect constitute a combination of cask failure mechanisms, impact velocities, and temperature ranges, which the EIS does evaluate. Accident scenarios are modeled in this fashion to accommodate the almost infinite number of variables that any given accident could involve. In the Draft EIS, for example, DOE evaluated the ability of large aircraft components (engines and engine shafts) to penetrate shipping casks. DOE considered both small military aircraft and commercial aircraft at

velocities representative of takeoffs and landings and at higher velocities. DOE found that, at lower velocities, these aircraft components would not penetrate a shipping cask sufficiently to cause a release of radioactive materials. Recent analysis of this event at higher velocities, however, indicate an increased potential for seal failure of the shipping casks. If seal failure were to occur, impacts to an urban area would be less than 1 latent cancer fatality in the exposed population.

Based on its revised analyses, DOE has concluded in the EIS that casks would continue to contain spent nuclear fuel fully in more than 99.99 percent of all accidents (of the thousands of shipments over the last 30 years, none has resulted in an injury due to release of radioactive materials). This means that of the approximately 53,000 truck shipments, there could be 66 accidents, each having less than a 0.01-percent chance that radioactive materials would be released. The chance of a rail accident that would cause a release from a cask would be even less. The corresponding chance that such an accident would occur in any particular locale would be extremely low.

- *Cask testing – Will DOE conduct full-scale testing of transportation casks?*

The NWPA requires DOE to use casks certified by the NRC when transporting spent nuclear fuel and high-level radioactive waste to a repository. A cask's ability to survive the tests prescribed by the regulations (10 CFR Part 71) can be demonstrated either through component analysis or through scale-model and full-scale testing to demonstrate and confirm the performance of the casks. The NRC would decide which level of physical testing or analysis was appropriate for each cask design submitted.

- *Repository design – Why didn't DOE analyze the latest design in the Draft EIS?*

In the Draft EIS, DOE evaluated a preliminary design that focused on the amount of spent nuclear fuel (and associated thermal output) that DOE would emplace per unit area of the repository (called *areal mass loading*). Areal mass loading was represented in the Draft EIS by three thermal load scenarios. The purpose of these scenarios was not to place a limit on the choices among alternative designs because, as stated in the Draft EIS, DOE expected the repository design to continue to evolve in response to ongoing site characterization and design-related evaluations. Rather, DOE selected these analytical scenarios to represent the range of foreseeable design features and operating modes, and to ensure that it considered the associated range of potential environmental impacts.

Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes. The result of the design evolution process was the development of the *flexible design* (which the Supplement to the Draft EIS called the Science and Engineering Report Flexible Design). Although this design focuses on controlling the temperature of the rock between the waste emplacement drifts (as opposed to areal mass loading), the basic elements of the Proposed Action to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain remain unchanged since the Draft EIS.

- *Hydrologic setting – DOE lacks an understanding of the hydrologic setting and should continue to study the site and surrounding region before making any decisions.*

DOE believes that it has sufficient information and understanding of the hydrologic setting to make an adequate determination of the potential environmental impacts from the Proposed Action. DOE, the U.S. Geological Survey, and others have been evaluating and assessing the hydrologic setting and associated characteristics at the Yucca Mountain site and nearby region for more than two decades. During this time, DOE has modified its site characterization program to reflect new information and assessments and to accommodate reviews by independent parties. Nevertheless, DOE recognizes that

additional information would refine its understanding of the regional groundwater flow system, and would reduce uncertainties associated with flow and transport in the alluvial, volcanic, and carbonate aquifers.

To obtain additional information, DOE has supported Nye County in the Early Warning Drilling Program to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain as well as the relationships among the volcanic, alluvial, and carbonate aquifers. DOE also has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex.

After completion of site characterization, DOE would institute a *Testing and Performance Confirmation Program*, elements of which would address the hydrologic system. The program would continue through closure of the repository.

- *Site disqualification – The Yucca Mountain site should be disqualified under 10 CFR Part 960 because subsurface fracturing would allow contaminated groundwater to reach the environment in less than 1,000 years.*

DOE's original 1984 site suitability guidelines (10 CFR Part 960) have been superseded by Yucca Mountain-specific guidelines (10 CFR Part 963) promulgated by DOE in 2001. In any event, information and analyses do not support a finding that the site would have been disqualified under the groundwater travel time disqualifying condition at 10 CFR 960.4-2-1(d). Under that condition, a site would be disqualified if the expected groundwater travel time from the disturbed zone (the area in which properties would change from construction or heat) to the accessible environment would be less than 1,000 years along any pathway of likely and significant radionuclide travel. The definition of groundwater travel time in 10 CFR 960.2 specifies that the calculation of travel time is to be based on the average groundwater flux (rate of groundwater flow) as a summation of travel times for groundwater flow in discrete segments of the system. As a practical matter, this definition provides for consideration of the rate at which most of the water moves.

DOE estimates that the median groundwater travel times would be about 8,000 years, and average groundwater travel times would be longer. These models indicate that small amounts of water potentially moving in "fast paths" from the repository to the accessible environment could do so in less than 1,000 years. However, the models and corroborating physical evidence indicate that most of the water would take more than 1,000 years to reach the accessible environment. Given this, DOE believes that the site would not have been disqualified under the groundwater travel condition at 10 CFR 960.4-2-1.

- *Repository performance – How can DOE possibly predict repository performance given data uncertainties, untested computer models, and the chaotic nature of the long-term processes?*

DOE acknowledges that it is not possible to predict with absolute certainty what will occur thousands of years into the future. The NRC regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the EPA has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE has designed its performance assessment to be a combination of mathematical modeling, and natural analogs. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic, and engineered components of the disposal system. In this way, DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts over thousands of years.

- *Disruptive natural phenomena – Commenters stated that earthquakes and volcanoes will cause releases of radioactive waste.*

DOE has analyzed the potential public health and safety impacts that could arise from natural events such as earthquakes and volcanic activity. The disruptive natures of earthquakes and volcanic activity differ materially, both in terms of probabilities (likelihood of occurrence) and the possible disruptive nature of the events themselves. Volcanism over the long-term life of the repository, with eruptions and magma flow, would be highly unlikely, while seismic activity and its consequent ground motion would be more likely to occur.

While the occurrence of events cannot be predicted exactly, risks can be estimated statistically. Computer simulations allow DOE to estimate risks from natural events. Thus, the EIS contains an analysis of the probabilities and effects of such events on radionuclide release, and the resultant potential human health impacts to the public.

Although DOE would design repository structures to withstand the ground movement associated with severe earthquakes, it estimated the impacts that could result from a “beyond-design-basis” seismic event that would result in the collapse of the Waste Handling Building and consequent damage to spent nuclear fuel assemblies. DOE determined the resulting impacts associated with this scenario would be small (primarily due to the physical form of the assemblies, reduced releases due to the building rubble, and distance to the nearest population). The underground engineered barriers would be far less susceptible to damage.

DOE also estimated the impacts of volcanic eruptions that could result in the release of volcanic ash and entrained waste into the atmosphere. DOE estimated the potential impacts on the nearest population, conservatively assuming (tending to overestimate) the direction and speed of wind transport of an ash plume, and determined that the potential for public health and safety impacts would be very small. DOE also determined that magma flows would have minimal impacts on the long-term performance of the repository.

### **S.4.3 Changes Made in the Final EIS**

As a result of public comments and the availability of new and updated information, changes were made to the Draft EIS and Supplement to the Draft EIS and are reflected in the Final EIS. Examples of these changes are the inclusion of:

- More information regarding potential impacts, particularly impacts associated with transportation of spent nuclear fuel and high-level radioactive waste within Nevada
- Use of a “representative” fuel assembly in the accident analysis
- Use of updated data, particularly population data in the impact analyses
- A more detailed discussion of the issue of potential impacts associated with negative perceptions about the repository project
- Use of updated versions of computer models for assessing human health and transportation impacts
- Corrections or editorial changes for accuracy and clarity
- Addition of an appendix that contains general information about transportation of radioactive materials not specifically used in the analysis, but provided for public information

- Addition of the U.S. Fish and Wildlife Service Biological Opinion as an appendix to the Final EIS
- Addition of a Readers Guide to help readers understand the Final EIS

As stated in the Supplement to the Draft EIS, “The fundamental aspects of the repository have not changed.” The differences in environmental impacts due to the changes noted above were minor. In most environmental resource areas, the impacts either stayed the same or were smaller than those presented in the Draft EIS or the Supplement to the Draft EIS. In those cases where the impacts were larger than previously presented (generally driven by the larger population used for analysis in the Final EIS), the increases were not materially larger.

## S.5 Environmental Consequences of the Proposed Action

To analyze the potential environmental impacts associated with the Proposed Action, DOE compiled baseline information for various environmental resource areas and examined how the construction, operation and monitoring, and eventual closure of a repository at Yucca Mountain could affect each of those environmental resources, and resulting impacts on human health. In considering the impacts on human health, DOE analyzed both routine operations and accident scenarios.

### ENVIRONMENTAL CONSEQUENCES

Under the regulations implementing the procedural provisions of the National Environmental Policy Act, an EIS should include a discussion of the *environmental consequences* of the Proposed Action and alternatives. The discussion of environmental consequences must include:

- Environmental *impacts* or *effects* (impacts are synonymous with effects under the regulations)
- Any adverse environmental impacts that cannot be avoided
- The relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity
- Any irreversible or irretrievable commitment of resources

*Short-term* consequences are those that could occur in the period before the completion of repository closure. DOE analyzed potential short-term impacts that could occur in resource areas as a result of performance confirmation, construction, operation and monitoring, closure, and transportation activities.

*Long-term* consequences are those that could occur after repository closure. DOE analyzed potential long-term impacts that could occur to human health and biological resources from radiological and chemical groundwater contamination for 10,000 years after repository closure. In addition, peak dose to 1 million years was estimated.

DOE conducted a broad range of studies to obtain or evaluate the information needed for the assessment of Yucca Mountain as a geologic repository. These studies have provided in-depth knowledge about the Yucca Mountain site and vicinity and provide sufficient information to aid in DOE decisionmaking. The Department used the information from these studies in the analyses described in this EIS. However, because some of these studies are ongoing, some of the information is incomplete. Further, the complexity and variability of the natural system at Yucca Mountain, the long period evaluated (10,000 years), and incomplete information or the unavailability of some information have resulted in uncertainty